point some 2500 miles in the interior, situated in the Great Sahara Desert.

At least one good observing station can be reached in Chile; a number are available in Brazil, and at least one in Africa. Between observations in Chile and those in Africa there would be an interval of over two hours. When it is remembered that the duration of totality will be over 4½ minutes, it will be seen how favorable are the circumstances of this eclipse. Photographs of the corona taken by parties in Chile, Ceara and Senegambia would go far toward solving some of those problems of the corona which seem ripe for solution at the present time. To make the results strictly comparable the photographic equipments should be similar, and the negatives developed by the same operator, using the same method of development.

In the matter of eclipse observation, as in other departments of astronomical work, an intelligent co-operation among astronomers of different nationalities would go far toward increasing the value of the results. The elaboration of some feasible plan for securing co-operation in the observations of this important eclipse might, it seems to me, be very properly undertaken by this Society, which had its practical beginning in the co-operation of observers of the eclipse of January, 1889.

WASHINGTON UNIVERSITY, January, 1891.

LUNAR WORK FOR AMATEURS.

BY THOMAS GWYN ELGER, F. R. A. S.

As it may undoubtedly be assumed that a majority of those who join a Society like this are desirous of undertaking active work of some description, and that all who possess suitable telescopes are anxious so to employ them as to add something, however little, to the general sum of astronomical knowledge whatever branch of observation they wish to pursue,—the following short paper on Lunar Observation may, perhaps, be acceptable to those who are thinking of turning their attention to this promising and attractive subject.

To the observer possessed of a moderate-sized telescope,—*i. e.*, an achromatic of from 4-in. to 8-in. aperture, or a reflector of from 6-in. to 12-in., the study of the Moon's surface

opens up a practically inexhaustible field for work, which, if he sets about it on a definite plan, cannot fail to be of more or less permanent value. It must be remembered that we really know very little about lunar details. Excellent charts have been published, showing all the principal "seas," walled and ringed plains, craters of various sizes, mountain ranges, together with ridges, rills and innumerable other features, but a very short experience with a good instrument, within the limits of size just mentioned, will suffice to show that the best of these maps is very far from being exhaustive, and that, if we take the trouble to make a special study of any particular formation, we shall find, long before much progress has been effected, that a number of hitherto unrecorded objects has been noted. No matter to which formation the observer directs his attention, this will be his experience, and he will discover, moreover, as he continues his scrutiny from lunation to lunation, that more and more objects will be revealed, as his eye becomes more and more familiar with the region he is studying. This education of the eye is not the least useful benefit he will acquire by devoting himself to a definite line of observation, as it will ultimately give him an immense advantage over desultory gazers, even though they be furnished with much larger instruments. It has been truly said, that the value of a telescope above a certain size, as a means of research, depends less upon its actual aperture than upon the man at the eye-piece, and in no branch of observational astronomy is the truth of this statement more strikingly exemplified than in selenography. As an illustration of the effect of the continued study of delicate lunar details, I may, perhaps, be pardoned for a brief reference to my personal experience. Some five and twenty years ago, becoming possessed of an excellent 4-in. achromatic, by COOKE, of York, I commenced to scrutinize the floor of the fine walled-plain *Plato*, and was disappointed and chagrined to find that, with all attention and under the best atmospheric conditions, only three or four of the light spots and one or two faint streaks were visible in the interior, while other observers, with very similar optical means, had detected very many more of these objects, and regarded those which I noted, as easy. A few weeks sufficed to show me, however, that the fault lay not with Mr. COOKE'S handiwork, but with myself; or, in other words, was due to want of experience and familiarity with the minute features of the formation; for, as time went on, additional light spots and streaks were revealed, so

that, ultimately, I saw as many as my fellow-observers. The training received by the eye, even in so short a time, was, in fact, tantamount to a notable increase in the light-giving and optical capacity of the telescope. My experience will, I think, be confirmed by that of many other observers.

The beginner, then, is strongly recommended to devote his attention to some particular lunar formation, and to make an exhaustive study of it under as many different phases of illumination as possible, selecting at first one of moderate extent and without very complicated surroundings. He should endeavor to sketch it from night to night, so that he may have a more or less accurate record of its appearance under various conditions. *Timocharis* and *Lambert*, in the *Mare Imbrium; Reinhold* and *Landsberg*, south of *Copernicus; Marius*, in the *Oceanus Procellarum; Taruntius* in the *Mare Fœcunditatis;* are all objects of a comparatively simple type, which will well repay careful observation. Commencing his work when the selected formation is in close contiguity to the morning "terminator," or ever-shifting division line between the illuminated and unilluminated portion of the Moon, that is, when the Sun is rising above the horizon of the object, he should watch the effects of the gradual illumination of its details, noting the lighting-up of the peaks or loftier portions of the ring and the projections of their shadows. As sunrise advances, the form and position of these shadows should be carefully sketched, the time of observation being accurately recorded, and the ridges, hills, clefts and other details duly noted and drawn. On the following night, if the weather permits, the work should be repeated, and so on, from night to night, as often as occasion offers, till he has a more or less complete series of pictures of the formation, extending from sunrise to sunset, when, it may be confidently asserted that, if ordinary care has been taken, his drawings will be of some selenographical value, and that he will have acquired a desire to extend his labors to objects of a more complicated description. This recommendation to the beginner may, perhaps, seem somewhat too exacting, and to make demands on time and patience which can rarely be satisfied. If this be so in any particular case, the programme can be easily modified by reducing the number of observations to (say) one at sunrise, one between sunrise and lunar noon, one under a still more vertical sun, and one or more near sunset. These will suffice to give a tolerably accurate idea of the character of the formation and its neighbor-

hood. The draughtsmanship of the observer has been assumed, because little progress can be made without some skill in the use of the pencil. If he does not possess this, an effort should be made to acquire it. Even in these days of celestial photography the camera has not yet succeeded in portraying innumerable lunar details revealed to the eye. Pencil and paper, moreover, are always available, and every observer should try to do his best with them, however distrustful he may be of his artistic powers. Many living selenographers who, at the commencement of their careers, were very indifferent draughtsmen, have subsequently become so skillful that all their drawings are of permanent value. Dr. WEINEK, in a recent number of this journal, has explained the method he adopts in the production of his beautiful drawings of lunar scenery. Very few observers, however, can hope to make any sensible approach to the excellent portraitures of this ardent selenographer, and must rest content with something very far short of such perfect pictorial representations. The first consideration is, of course, accuracy, and then comprehensiveness. The position of every feature shown should be fixed either by micrometrical measurement or by careful alignment, and its apparent size estimated, either in terms of a diameter of the formation with which it is associated, or of that of some other object whose relative dimensions have been so determined.

Some little experience is needed in order to appreciate the true character of lunar details,—*e. g.*, to avoid mistaking a narrow valley, or cleft, for a ridge, the shadow of a mountain mass for a deep depression, a hollow between rocks for a true crater, and so forth; and it is also very necessary to realize the actual size of the objects examined. From a want of this consideration, we are apt to overlook the significance of much that we see, and to greatly underrate the real dimensions of what appear to be insignificant details, regarding, for instance, what are really large, isolated mountains, as hillocks or mounds; radiating hills, three or four miles across, with intervening valleys of equal width, as "lava streams," and so on. In the case of a vast circumvallation like *Ptolemäus*, for example, it adds immensely to the students' comprehension of the size and character of the multitude of features it includes, both on its border and interior, to know that, speaking roughly, the area of the floor, some 115 miles in diameter, is 9000 square miles, or about equal to that of the English counties of York, Westmoreland and Lancaster combined, and that the

bright crater A, which is such a conspicuous object thereon, is at least four miles in diameter and covers an area much larger than that occupied by the town of Sheffield and its suburbs. This question of scale should never be overlooked, whether the formation under examination be large or small.

Having acquired some practice in the observation of objects of moderate size and simple character, the observer should proceed to the study of another of the great walled-plains, or of some definite region presenting features of interest. Here the co-operation of several amateurs is very desirable, and not only contributes largely to the interest of the work, but to the possibility of doing far more during the course of a lunation than could be otherwise accomplished. Co-operation, of course, necessitates a director to organize the plan of observation, and to receive and discuss the results; but such an individual should be easily found among the members of a society including so many telescopists as the Astronomical Society of the Pacific. By an arrangement of this kind individual progress will be assured, and selenography will receive an impulse in the right direction. It is not desirable to lay down too rigid a system for directing the labors of such an association of lunar observers. Much should be left to be governed by individual tastes, optical means, and the capacity of the workers; the only strict stipulation being that each observer should undertake definite work of some description, and avoid merely spasmodic and desultory observations, which never lead to any useful result, but usually tend, in this and other branches of observational astronomy, to the ultimate abandonment of the telescope in favor of some other hobby or scientific toy.

One of the first requirements of the lunar observer is a good map of the Moon. BEER and MÄDLER'S large chart, 37½ in. in diameter, in four sections, with special maps on a larger scale of *Petavius*, *Hyginus*, *Triesnecker*, etc., will be found most generally useful; or, in default of this, their smaller map, 12½ in. in diameter, which is wonderfully accurate so far as it goes, but is somewhat overcrowded, owing to the smallness of the scale. NEISON'S Moon, the standard work on the subject in the English language, includes a map 24 in. in diameter, in twenty-two sections, which is also of great excellence; but the best for those who are able to pursue the subject with the aid of moderately large telescopes, is undoubtedly the magnificent chart due to the labors of the late Dr. SCHMIDT, of Athens. This is six Paris feet in

diameter, and is divided into twenty-five sections. Notwithstanding the coarse style of reproduction adopted, this is the clearest and most comprehensive, showing a vast amount of detail omitted in the other maps. The student should also acquire as many good photographs of the Moon as possible, taken under different phases, as they are very useful as affording reliable representations of the coarser features of the various formations, thus furnishing him with the means of drawing their outlines, etc., at his leisure, preparatory to his own telescopic scrutiny of them, and thus saving time and trouble. They are, besides, invaluable in giving the true positions of salient points, and as a check on the accuracy of his work.

A few words may now be said to those interested in selenography who have decided, either individually or in co-operation, to follow some definite plan of procedure, as to certain lunar details which will repay systematic observation.

Walled-plains and large enclosures.—With the exception of *Plato, Archimedes, Hipparchus* and one or two others, our knowledge of the details of these formations is so slight that an experienced observer, with moderate optical means, may, on a favorable night, detect many interesting features unrecorded on the maps. Taking *Ptolemäus*, for example, as one of the most familiar of lunar objects, near the center of the disc; many gaze on this magnificent wall-plain without, perhaps, suspecting that the features shown on the floor in SCHMIDT'S elaborate map amount to barely half the number that have been detected since its publication, and one may be tolerably sure that when the results of the study of this formation, now in progress under the auspices of the British Astronomical Association, are collected, very many more objects will be recorded. As regards *Plato* and *Archimedes* again, no one imagined that the floors of these formations, so sparingly covered with spots, etc., in the maps of MÄDLER and SCHMIDT, include a most remarkable system of crater-cones, craterlets, bright spots and light streaks. We may, therefore, reasonably conclude that what has been found to be the case with respect to these formations will hold true with respect to others, and that many, at present unsuspected features, will be brought to light when they are systematically surveyed and mapped. The accurate delineation and cataloguing of details of this description is of great importance in determining the vexed question of change. Unfortunately photography can, at present, render no assistance

here. Some observers believe, and the writer agrees with them, that the occasional invisibility of minute features on the floors of formations like *Plato* and *Ptolemäus* can only be satisfactorily explained by the existence of low-lying exhalations hanging over and obscuring them. Nothing short of an exhaustive study of the interiors of walled-plains of this type, involving careful measurements and alignments of the objects detected thereon, will solve this problem of lunar physics.

With respect to the coarser features, such as wide valleys, passes, depressions, landscapes, etc., etc., which are very generally found in connection with the great walled-plains, much more is required to be known about them and their relation to the border with which they are associated. We want, in short, to obtain as accurate an idea as possible of the structure of these vast circumvallations and some insight into their surface geology (if I may use the expression). Though the value of careful drawings of the shadows of peaks and other objects under different solar altitudes, accompanied by a note of the times when they assumed the form and position shown, has already been briefly referred to, I would again accentuate the importance of this kind of observation. If we possessed, which we do not, except in a few cases, accurate drawings of prominent peaks, it would be quite possible to detect the occurrence of landslips or other catastrophes by changes in the outline and extent of the shadows. Some knowledge of sciagraphy, or the laws which govern the forms of the shadows of objects, will be also found very useful to the lunar observer, and he is advised to experiment for himself on the various shapes which the shadows of objects assume when projected on a plane surface. It will then become apparent that very erroneous conclusions as to the actual form and altitude of lunar peaks, etc., are often drawn from a want of thought on this matter. Another point in this connection is not unfrequently overlooked, *viz:* That the form and extent of a shadow is not only determined by the object to which it is due, but also by the shape and inclination of the surface on which it falls. This is very important to be borne in mind with respect to the Moon, though it is often ignored as a factor in dealing with lunar shadow measurements.

Maria: There is ample scope for useful work in connection with these monotonous, dark regions, which has not, as yet, been attempted systematically, except in the case of the *Mare Seren-*

itatis, and to a more limited extent in a few other instances. Not only do these so-called "seas" include many craters and depressions, large and small, deserving careful scrutiny, but they exhibit differences of tint under various angles of illumination, not apparently due to variations in the solar altitude, which call for sustained investigation. Any good achromatic of from 3-in. to 4-in. in aperture, or reflectors of equivalent capacity, may do good service in this branch of selenography, though it must be confessed that in the absence of some satisfactory standard, free from the liability to physiological errors, tint observations are involved in some difficulty. The employment of an eye-piece, similar to that employed by DAWES for solar observation, so as to minimize the possible effects due to extraneous light, might, as suggested by PROCTOR, be tried to advantage, but an equally pressing requirement is an invariable and absolute scale of tints, and this is, unfortunately, not as yet forthcoming. Under a high light and good definition, some of the *Maria* seem to be covered with innumerable bright points and a network of silvery streaks of great delicacy, which have apparently no relation to objects visible in the same situations at other phases. Perhaps close investigation might tend to explain these phenomena. Other regions display decided traces of color, other than the various shades of grey which characterize the general surface of the *Maria*. Then there are the ridges which are found in all the "seas," and which, in many instances, seem to bear a definite relation to their borders (being more or less concentric with them) and to be physically associated with the small craters on their flanks and summits. Observers very indifferently furnished may do good service in studying these ridges from the time they are first illumined by the lunar morning sun till they are barely visible under a higher light. It is hardly necessary to specify any special objects of this class, as they are so numerous that the observer may easily choose some particular ridge, or group of ridges, for scrutiny, but those in the *Mare Humorum*, in the neighborhood of *Kepler* and *Marius*, in the *Mare Procellarum*, and in the *Mare Serenitatis* are especially noteworthy. Certain obscure rings, having the form and other characteristics of ring-plains, but lacking their brightness, and being scarcely distinguishable in tone from the surrounding region, may occasionally be detected on the *Maria*. Their borders are so low that they appear like mere scars on the grey surface. The work of cataloguing and describ-

ing these somewhat abnormal features would be a useful occupation for the amateur with a moderately large telescope.

Clefts, or Rills: These enigmatical furrows are found in almost every part of the Moon's visible superficies, but more frequently on the floors of large enclosures and close to the borders of the *Maria*, than elsewhere. They vary in length from ten to twelve miles to 300 miles, or even more, as in the case of the great *Sirsalis rill*, near the eastern limb; in width, from 500 yards to a mile and upwards; and their depth, in some instances, has been estimated at 300 or 400 yards. About a quarter of a century ago SCHMIDT catalogued 425 of these features, but it is probable that, if a complete list were now prepared, this number would be doubled, at least. The extreme delicacy of most of these objects necessitates the employment of telescopes which will bear high powers in their examination. Still, good work may be done with a 5 or 6-in. achromatic and a S. O. G. reflector of 8 or 9-in. aperture. A few may be glimpsed with much smaller apertures, as, for example, the fine cleft running from the central mountain of *Petavius* to the southeast wall of this formation, which can be seen under a low sun with a 2-in. achromatic; and the beautiful *Ariadæus* cleft, south of *Julius Cæsar*, which is, as regards its coarser sections, a tolerably easy object in a 3½-in. achromatic; but, as a rule, they require good optical means, a practised eye, and excellent atmospheric conditions to be satisfactorily traced. There is a wide field open to the student here, as there are few rill systems which have been accurately or exhaustively mapped, and a few nights' devotion, even to the best-known groups, generally results in the discovery of additional clefts or of new details in connection with those already known. The *Triesnecker* rills, those on the east side of the *Mare Tranquilitatis*, between *Sabine* and *Maclear;* the system round *Ramsden;* those between *Gassendi*, *Mersenius* and *Cavendish*, may be mentioned as groups which require mapping on a large scale and cataloguing. As features of a somewhat similar type, the "faults" in various parts of the lunar surface deserve attention from the observer. The well-known "railroad" (so striking an object under a low sun east of *Thebit*), is the most noteworthy example, but there are many others of a less imposing character. In some cases they are apt to be confounded with straight ridges, and in others (as, for example, the fault which crosses the floor of *Plato* obliquely from N. W. to S. E.), they

are only traced with difficulty, even under the most favorable circumstances. Very often the apparent dislocation of the wall of a formation on opposite sides points (as in the case of *Plato*) to the existence of a fault. *Helicon*, a small ring-plain in the *Mare Imbrium*, is also a remarkable example of faulting, well deserving of examination at lunar sunrise.

Ray Systems and Nimbi: Besides the light markings on the floor of certain formations, such as *Plato*, *Archimedes*, *Ptolemäus*, and many others, which not only require considerable excellence in the telescope used and exceptionally good definition, but also, as before remarked, an educated eye to trace them effectually, there are the well-known ray systems and nimbi, which may be studied under much less rigorous conditions. *Tycho*, *Copernicus*, *Kepler*, *Anaxagoras*, *Aristarchus*, *Olbers*, *Byrgius A*, *Zuchius*, *Autolychus*, *Aristillus*, *Proclus*, *Timocharis*, *Furnelius A* and *Menelaus*, are among the most interesting formations exhibiting these phenomena.

There is yet another matter to which the beginner may turn his attention, which has been strangely neglected by selenographers, *viz:* The portraiture of mountains and valleys when seen in outline on the Moon's limb. Accurate sketches of these would be of great interest and value, but they require considerable magnifying power, and involve micrometrical measurements for the purpose of subsequent identification. Still, something may be accomplished without such aids, provided, as is not unfrequently the case, the mountains delineated are in close contiguity with known objects. In making limb observations the observer should be on the watch for abnormal outlines, as, for example, the flattenings detected some years ago by the Rev. H. COOPER KEY on the western limb. These, instead of being arcs of a circle, form straight sections, like the sides of a polygon.

In conclusion, the beginner is advised to keep a very open mind as regards the physical constitution of the Moon. Preconceived notions are often apt to bias observations and to warp the judgment. It is far better to enter on selenographical work untrammelled by theoretical cobwebs, and intent only on faithfully recording whatever is observed. A short spell of patient, systematic observation will teach the observer to estimate the value of current hypotheses and will satisfy him that a very much more intimate acquaintance with lunar details is needed before many

vexed questions, relating to the actual condition of the Moon's surface, or its history in the past, can be regarded as approaching solution.

A FEW HINTS TO BEGINNERS IN SOLAR OBSERVATION.

By Miss E. Brown.*

In these days of widespread interest in astronomy there are, probably, many readers of popular essays, or of scientific magazines, who would gladly pass from the ranks of mere readers into those of actual workers, but who are deterred from making the first plunge by the impression that to the inexperienced beginner the accomplishment of any useful work is an almost hopeless aim; that to enroll themselves among real observers needs not only courage and confidence, but technical skill, or mathematical knowledge; and they probably feel that the mere play-work of an amateur, taken up and laid aside on the spur of the moment, and without definite object, will retain but a slender hold on their interest.

It is to such that I venture to offer a few words, based on personal experience, to show how a beginner *may*, from very small beginnings, if only he possess the two most necessary qualifications—accuracy and perseverance, attain to be ranked among those whose work will be welcomed and accepted by the greater scientific lights as a really useful contribution to astronomical knowledge.

When I first took up solar work, I possessed no observatory and no equatorially mounted telescope. I had only an old refractor, of 3-inch aperture, which had already seen a good deal of service, and which I used chiefly for a very elementary study of the Moon and planets, in accordance with the advice of the Rev. T. W. Webb, in his "*Celestial Objects for Common Telescopes*," to avoid looking at the sun "until hand and eye had acquired experience elsewhere."

It was a description given in "Proctor's Half Hours with the Telescope," of a method of observing sun-spots by projection, that induced me, a little later, to take up systematically that

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